



The Lunar Exploration Analysis  
Group  
(LEAG)

# ***LEAG and the Vision for Space Exploration***



**Clive R. Neal**  
University of Notre Dame



# LEAG Leadership

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Vice Chair:

Chip Shearer, UNM

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Executive Secretary:

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SMD:

Kelly Snook, HQ

SOMD:

Michelle Gates, HQ

Lunar Community Liaison:

Steve Mackwell, LPI

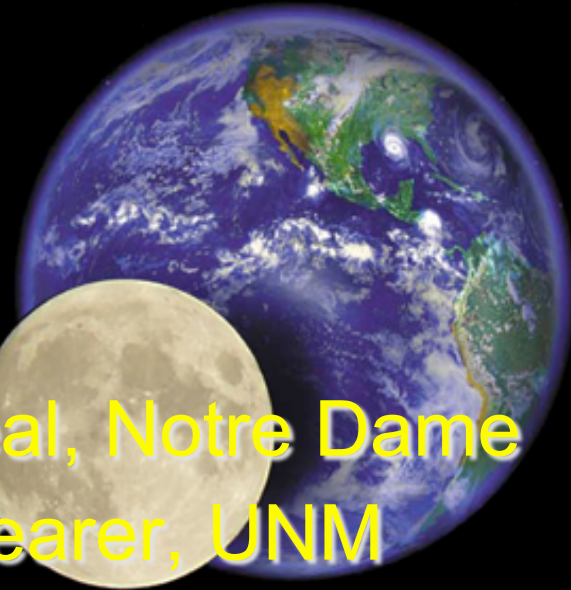
ISRU Subgroup Chair:

Jerry Sanders, JSC

Commerce Subgroup Chair:

Paul Eckert, Boeing

<http://www.lpi.usra.edu/leag/>



# Lunar Exploration Analysis Group (LEAG)

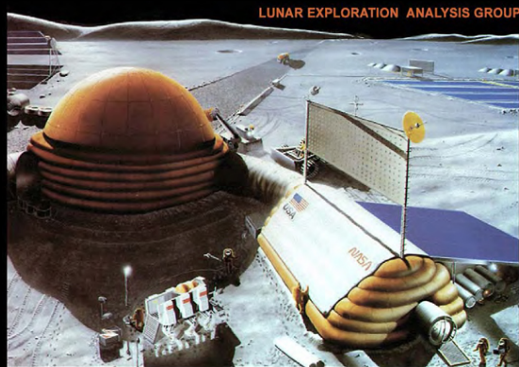
## Terms of Reference

The Lunar Exploration Analysis Group (LEAG) is responsible for analyzing scientific, technical, commercial, and operational issues associated with lunar exploration in response to requests by NASA. The LEAG serves as a community-based, interdisciplinary forum for future exploration and provides analysis in support of lunar exploration objectives and their implications for lunar architecture planning and activity prioritization. It provides findings and analysis to NASA through the NASA Advisory Council (the Council) within which the LEAG Chair is a member of the Planetary Science Subcommittee (PSS).

<http://www.lpi.usra.edu/leag/>







LEAG

# The Lunar Exploration Roadmap



## *Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2008*

A Community Effort Coordinated by the  
Lunar Exploration Analysis Group  
(LEAG)



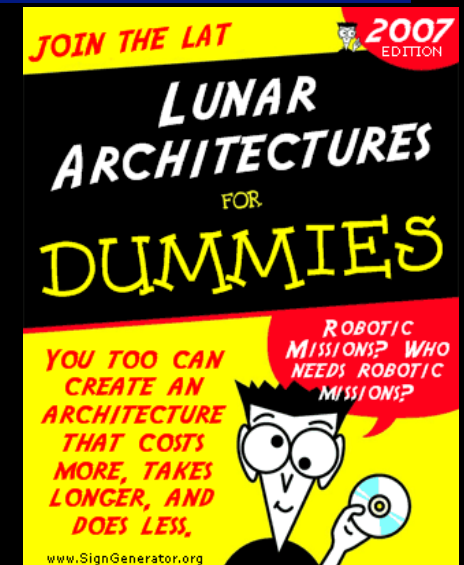
# Lunar Exploration Roadmap

## The Charge from the NAC

The Science Committee recommends that the Lunar Exploration Analysis Group (LEAG) be tasked to prepare a “Lunar Goals Roadmap” that maps science goals to objectives, and to observations and measurements. This roadmap should include an assessment of needed technology developments, areas of potential coordinated activities for commercial and international participation, and potential feed-forward activities for the exploration of Mars and beyond.

*With input from:*

- Lunar Geoscience Working Group, 1986
- LExSWG Reports, 1992, 1995
- ISRU Roadmap, May 2005
- Global Exploration Strategy Workshop, April 2006
- NASA/NAC Workshop on Science Associated with the Lunar Exploration Architecture, Feb. 2007
- NRC Science Context for Exploration of the Moon, 2007



# *Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2008*



**IMPORTANT:** NASA needs an exit strategy from the Moon that allows it to get to Mars and beyond, but doesn't abandon the infrastructure it has built up, which can still be used for science purposes.

Commercial on-ramps are vital – some of these center around ISRU capabilities, which are also important for the “feed-forward” focus on Mars.





# ***Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2008***

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## **Themes: Why are we going to the Moon?**

**Theme 1:** Pursue scientific activities to address fundamental questions about the solar system, the universe, and our place in them.

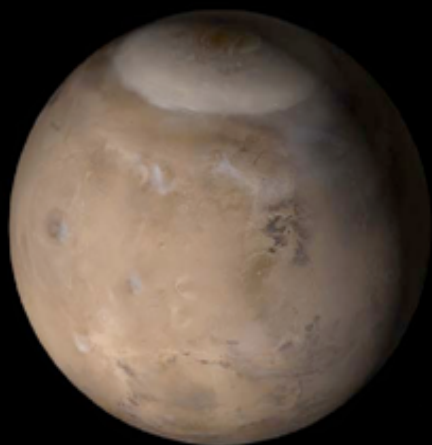
**Theme 2:** Use the Moon to prepare for future missions to Mars and other destinations.

**Theme 3:** Extend sustained human presence to the Moon to enable eventual settlement.





# NUMBERS DO NOT INDICATE PRIORITIZATION / TIMING!





# ***Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2008***

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the Lunar Exploration Analysis Group



## **Themes: Why are we going to the Moon?**

**Science Theme:** Pursue scientific activities to address fundamental questions about the solar system, the universe, and our place in them.

**Feed-Forward Theme:** Use the Moon to prepare for future missions to Mars and other destinations.

**Sustainability Theme:** Extend sustained human presence to the Moon to enable eventual settlement.



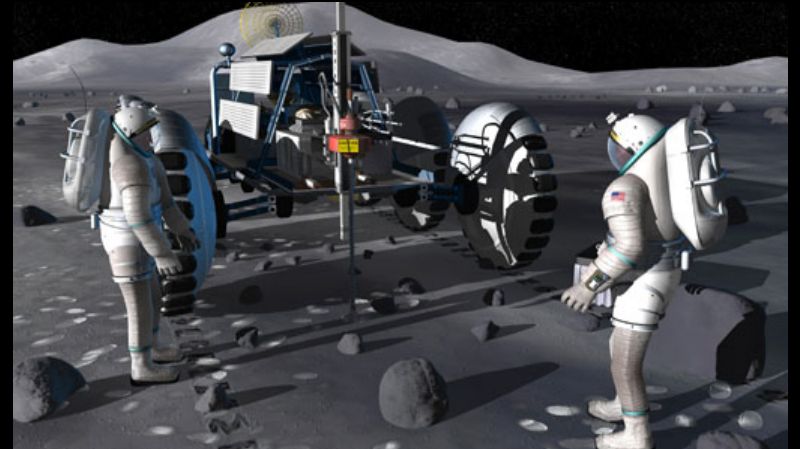
# ***Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2008***

A Community Effort Coordinated by the Lunar Exploration Analysis Group



## **Crosscutting Themes:**

- Learn to live and work successfully on another world.
- Expand Earth's economic sphere to encompass the Moon, and pursue lunar activities with direct benefits to life on Earth.
- Strengthen existing and create new global partnerships.
- Engage, inspire, and educate the public.



# ***Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2008***

**Theme (1): Pursue scientific activities to address fundamental questions about the solar system, the universe, and our place in them.**

## **Goals**

- Understand the formation, evolution and current state of the Moon.
- Use the Moon as a “witness plate” for solar system evolution.
- Use the Moon as a platform for astrophysical, heliophysical, and earth-observing studies.
- Use the unique lunar environment as a research tool.





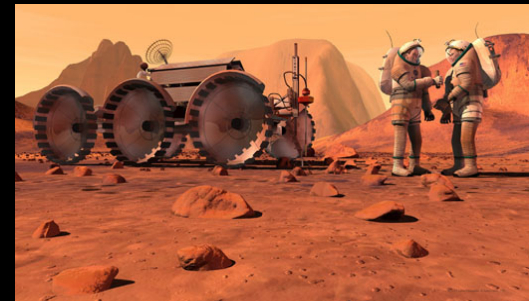
# ***Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2008***



**Theme (2): Use the Moon to prepare for future missions to Mars and other destinations.**

## **Goals**

- Identify and test technologies and systems on the Moon to enable robotic and human solar system science and exploration.
- Use the Moon as a test-bed for mission operations, and exploration techniques to reduce the risks and increase the productivity of future missions to Mars and beyond.



# Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2008



**Theme (3):** Extend sustained human presence to the Moon to enable eventual settlement.

## Goals

- Identify, develop, and mature systems, technologies, tools, and operational procedures and deploy initial infrastructure capabilities to the Moon
- Reduce the cost of re-supply and dependency on Earth.
- Facilitate development of self-sustaining economic activity.
- Keep humans healthy and safe off-planet.



# ***LEAG @ The NLSI Conference***

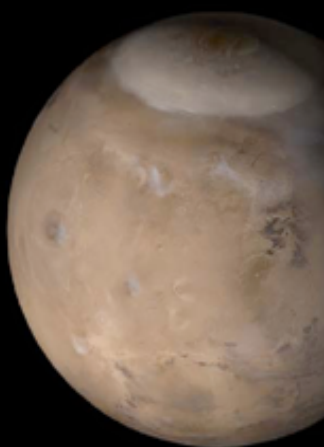
Plenary – each **Theme** and associated **Goals** were introduced and expounded upon during the ensuing talks.

Breakout Sessions – handouts with **Goals & Objectives**.

- Are these correct? What is missing?
- First cut: Prioritize the **Objectives** – **high, medium, low**;
- First cut: time phasing of **Objectives**:  
**Early** = pre-humans (must be done to enable human exploration;  
**Mid** = done by humans on short stays (<14 days)  
**Late** = done when humans are there for long stays.

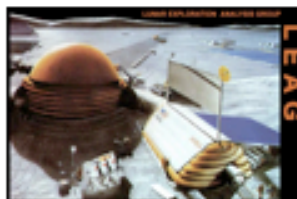






# LUNAR EXPLORATION ANALYSIS GROUP

<http://www.lpi.usra.edu/leag/>



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LEAG at the NASA Lunar Science Conference  
22 July, 2008

## The Lunar Exploration Roadmap:

*Exploring the Moon in the 21st Century:  
Themes, Goals, Objectives, Investigations, and  
Priorities, 2008*

### THEME 3: GOALS AND OBJECTIVES

*Extend sustained human presence to the Moon to  
enable eventual settlement.*

**GOAL 3A:** Identify and develop systems, technologies, tools, & operational procedures and deploy "initial" infrastructure capabilities to the Moon.

**Objective 3A-1:** Develop a capable space transportation system

**Objective 3A-2:** Identify and characterize lunar locations where permanent facilities would be established.

**Objective 3A-3:** Provide adequate living quarters for human crews.

**Objective 3A-4:** Develop the capability to use lunar resources.

**Objective 3A-5:** Develop effective general infrastructure systems.

**Objective 3A-6:** Develop robust surface transportation & navigation systems.

**Objective 3A-7:** Establish adequate power systems on the Moon.

**GOAL 3B:** Reduce the Cost of Re-Supply and Dependency on Earth.

**Objective 3B-1:** Develop technologies and systems that minimize the necessity of resupply from Earth.

**Objective 3B-2:** Construct facilities, manufacture hardware, materials, chemicals and other products on the moon using lunar resources.

**GOAL 3C:** Facilitate development of self-sustaining economic activity.

**Objective 3C-1:** Commercial development of lunar infrastructure.

**Objective 3C-2:** Media, entertainment, and recreational opportunities.

**Objective 3C-3:** Establish an export business from the Moon.

**Objective 3C-4:** Explore new methods of collaboration between and among industry, government, and academic entities.

**GOAL 3D:** Use the unique lunar environment as a research tool.

**Objective 3D-1:** Characterize aspects of the lunar environment important for human health and safety.

**Objective 3D-2:** Incorporate results from basic biological research (Goal 1D) into the design of lunar settlements.

**Objective 3D-3:** Provide safe and enduring habitation systems to protect individuals, equipment, and associated infrastructure.

**NOTE:** While the Themes, Goals, and Objectives are numbered, this should not be read as being an indication of priority.



# ***Exploring the Moon in the 21st Century: Themes, Goals, Objectives, Investigations, and Priorities, 2008***



Themes and Goals on the web for public comment until **25 July**:

[https://www.lpi.usra.edu/survey/LEAG\\_ThemesGoals/](https://www.lpi.usra.edu/survey/LEAG_ThemesGoals/)

**Login:** leag **Password:** moonorbust

Five SATs are in progress.

Face-to-face meeting, 3-5 Sept. @ the LPI.

Web-based community input.

Unveil the **1<sup>st</sup> draft Roadmap** at the **October LEAG meeting**.

# LEAG ANNUAL MEETING

Joint with ILEWG and Space Resources Roundtable.

October 28-31, 2008; Radisson at the Port, Cape Canaveral, Florida.

All sessions focused on questions [e.g., What technologies need to be developed now in order to be ready for human return to the Moon (and beyond)?]

<http://www.lpi.usra.edu/meetings/leagilewg2008/>





# *The “Lunar-L”*



The “Lunar-L” is an e-mail list server that facilitates communication between lunatics worldwide.

>400 subscribers.

A Lunar-L documents web site:

<http://www.nd.edu/~cneal/Lunar-L>

To subscribe, e-mail [neal.1@nd.edu](mailto:neal.1@nd.edu)



# ***Post Roadmap Plans***



## **Mission-SAT:**

- ISRU Technology Demonstration on the Lunar Surface
- Landed mission at Lunar Poles

## **Techno-SAT**

**Continued refinement of roadmap!**

